

## Charge Injection Study of the USA Brass Board Electronics

SLAC Astro Grav Note #26  
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On April 15-17, 1998 we spent time at NRL injecting various size pulses of charge into the wire chamber inputs of the USA electronics. The primary goal of this measurement was to test the USA electronics' response to pulses much larger than nominal (such as from a Carbon or Nitrogen cosmic ray). This report will summarize our conclusions and ask some other questions.

Figure 1a,b,c are the schematics for the Preamplifier, Summing, and Pulse Stretcher boards. Each of these resides in its own little box and its output connector may be probed using a breakout board. There are three preamp boxes, each with two preamps. These preamps service wires 1A (A wire of chamber Layer 1), 1B (B wire of chamber Layer 1), 2A (A wire of chamber Layer 2), 2B (B wire of chamber Layer 2), and the Perimeter Veto wire. The schematics are labeled with where scope pictures were taken.

Charge was injected by putting a negative going step voltage on a 200 pf capacitor into the appropriate xray wire or perimeter wire input. The circuit is drawn on Fig 1a. This injected  $Q=CV$  worth of charge (negative on the negative going edge of the pulse and positive on the positive going edge of the pulse 1 msec later). This was repeated at a slow rate of 100 Hz so as to allow lots of time (9 msec) for the effects of the positive charge injection to go away. Charge was injected in a time equal to the rise time of the voltage pulse. Two different pulse generators were used. The first put out a square wave so that both edges injected  $Q=CV$  in short times (typical 50 nsec). The second pulse generator was a tail pulser and generated a short (~50 nsec wide) current pulse on the leading negative edge of the pulse and a much smaller and longer positive current during the  $\tau=1$  msec tail.

Two different types of measurement were made. In the first, oscilloscope pictures were taken at various positions in the circuit (the input voltage pulse, the preamp board output, the summing amp output, the 15 usec one shot output) of the response to the injected pulses. In the second, two pulses were input with a time delay between them. Typically 100 sec of mode 3 data were then recorded with the DAQ for each configuration of pulse heights and time delay. The initial goal of this study was to measure the deadtime initiated by various amplitude first pulses (i.e.: veto pulses) so as to better be able to Monte Carlo the USA response to a Poisson background.

Figure 2 shows scope photos of the one preamp output for inputs of .4, 2, 20, 200, and 1000 pC. We also varied the rise time of the input voltage pulse to see if it affects the shape of the preamp output pulse. When the rise time of the input voltage pulse was varied between 50 and 200 ns, no change in the preamp output pulse was observed (ie. the preamp is behaving like a  $\sim 2$  usec time constant integrator should). Notice that the preamp output does not ring, even for the large 1000 pC input. The preamp output goes positive (which is the polarity later discriminators and ADCing uses), then negative (which it has to do since the circuit is AC coupled and there must be equal positive and negative areas), and then never goes positive again. Since it never goes positive again, it can't refire discriminators and can't cause additional deadtime intervals. However, the baseline is suppressed for some time during the negative swing return to zero. A second pulse into any xray wire, coming at greater than the 15 usec deadtime, will ride on this baseline and may not make it over the  $\sim .14$  v discriminator, thus not firing the 15 usec one shot again. The second pulse will have to come later when the baseline has returned closer to zero in order to be detected. The ADC will also return a smaller number for a pulse riding on a suppressed baseline. Thus the deadtime will be a function of the first pulse height, the second pulse height, and the pulse height cut put on the ADC. To incorporate this in the Monte Carlo, a function will be written that returns whether the second pulse is detected based on the two pulse heights, the ADC cut, and the time between the two pulses.

Figure 3 shows scope photos of the summing amp output for wire inputs of 2, 20, and 200 pC. The output simply follows the input and introduces no new ringing.

Figure 4 shows the one shot output for 2 and 1000 pC wire inputs. Notice that the width remains 15 usec at both pulse heights and that there is no retriggering even for the 1000 pC input.

Figure 5 is for two 2 pC pulses being put into two different xray wires with a time delay between them. Notice that the width of the second pulse is reduced when it begins close to the end of the first pulse's 15 usec. No shortening is visible for a gap of 10 usec. The second pulse shortens to 14 usec for a gap of 5 usec, and it shortens to 12 usec for a gap of 1 usec. This shortening is due to the one shot timing capacitor not having enough time to recharge. We also found, to the accuracy of the scope, that the first pulse was never stretched (retriggered) no matter how close the second pulse came.

### Summary of Conclusions

- 1) The preamp outputs are well behaved. The output never swings positive a second time up to the largest (1000 pC) input pulse used.
- 2) A hit on an xray wire generates a 15.6 usec deadtime for following hits on any xray wire.

3) A hit on the perimeter wire (with no simultaneous xray wire hit) generates deadtime between 6 and 8 usec for following hits on any xray wire. This deadtime was measured for a 2 pC veto pulse and a 2 pC xray wire pulse. For a 200 pC xray wire pulse the deadtime is <10 usec (we did not take measurements at shorter time delays).

4) The first pulse on an xray wire causes a suppressed baseline on the signal out of the summer that goes to the one shot discriminator and ADC. A later pulse on any xray wire rides on this suppressed baseline. It may not fire the one shot ADC and thus not be detected. If detected, it may be recorded as slightly less than its true pulse height by the ADC. For a second 2 pC pulse coming as soon afterward as it can to the first pulse without being vetoed (ie. 15.6 usec), the second pulse will be detected if the first pulse is <240 pC. For larger values of the first pulse the deadtime starts to increase. For example, if the first pulse is 400 pC and the second is 2 pC, the deadtime is ~150 usec. In Figure 6 if pulse 2 comes any closer to pulse 1, pulse 2 will not fire the one shot.

5) The second hit on any xray wire will get the ADC reading from the first xray wire hit if the second xray comes ~15 usec after the first xray.

That is:

If the second comes 14 usec after the first, the second is vetoed.

If the second comes 15 usec after the first, the second gets the first's pulse height.

If the second comes 16 usec after the first, the second gets its own pulse height.

6) The gain of the Brass Board Electronics (the gain potentiometers into the summing amp were used as found) was deduced to be 33 pC into an xray wire = full scale on the ADC. If the HV is set so that full scale ~ 17 keV, then 2 pC~1 KeV.

7) Pulses  $\geq 200$  pC on an xray wire self vetoed (presumably by cross talk to other preamps) and were not detected.

### Some Outstanding Questions

1) The chamber HV will be set so that how many KeV of energy deposited in the chamber will correspond to how many pC of injected charge?

2) How many pC of injected charge correspond to full scale in the flight electronics (ie. the potentiometer settings of the summing amp) ?

3) Can someone deduce the preamp gain of 2.4 volts / 20 pC from the components shown on the schematic?

### Implications for the Experiment

- 1) The perimeter wire veto deadtime of  $\sim 7$  usec is not equal to the xray wire deadtime of 15.6 usec as was thought before. This will introduce corrections (probably small) into the power spectrum at high perimeter veto rates.
- 2) There are energies for which the xray wire deadtime varies depending on the energies of both the first and second pulses. A function for this dependence must be written for the Monte Carlo. It depends on knowing the correspondence between energy and injected charge.
- 3) If two events come  $\sim 15$  usec apart, the second has a false energy value. This affects the energy spectrum.

Figure 1a

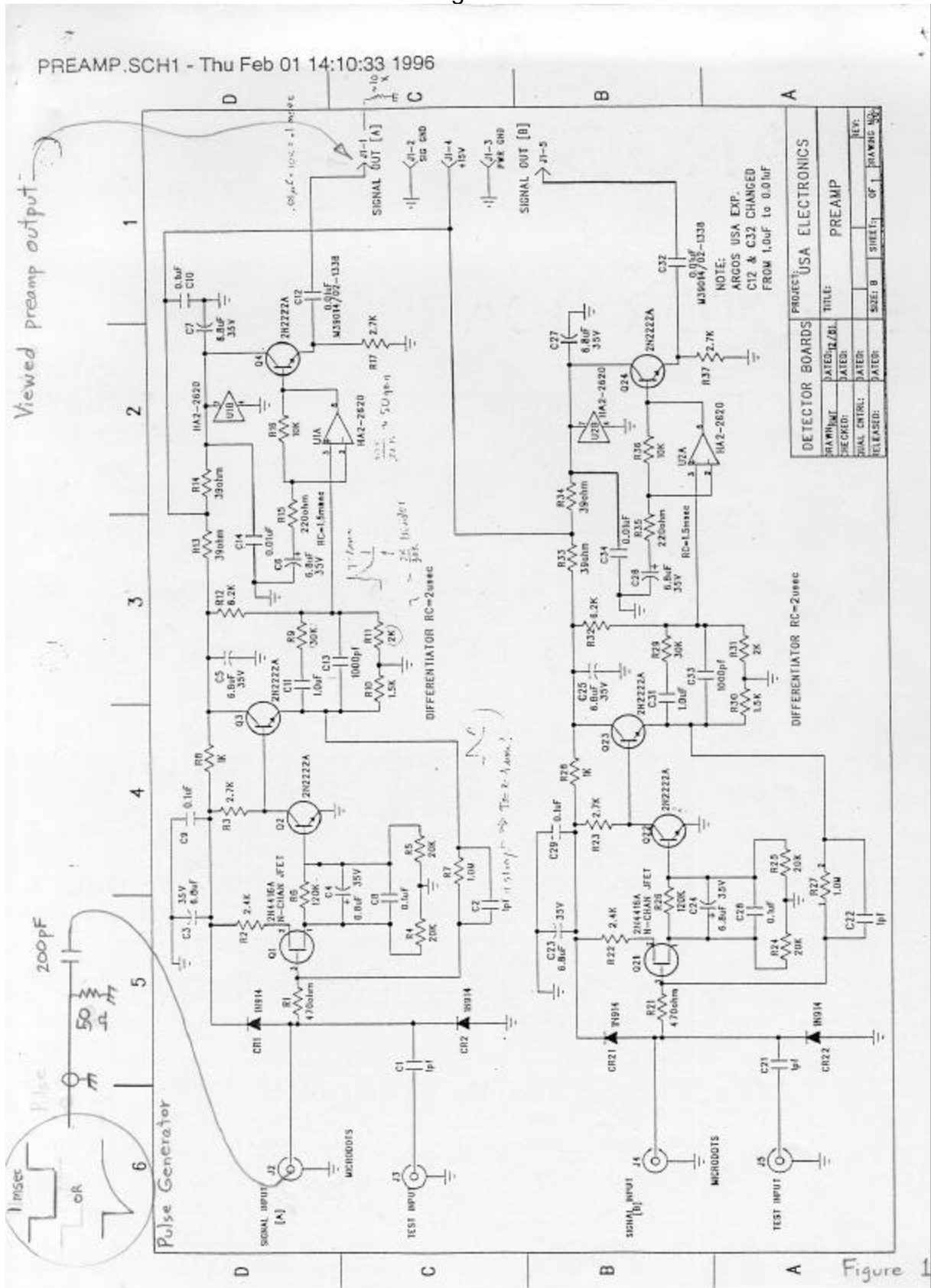


Figure 1b

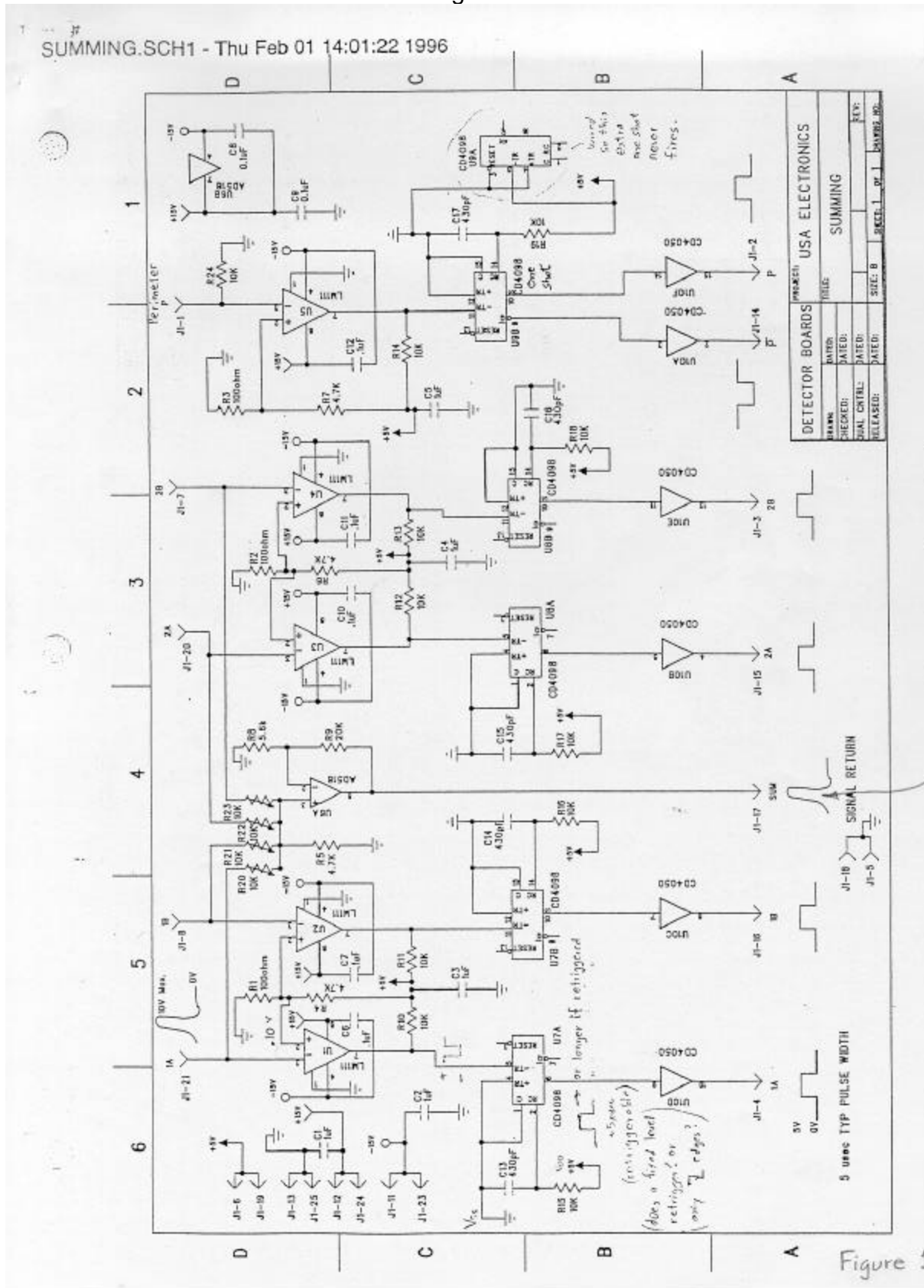


Figure 1c

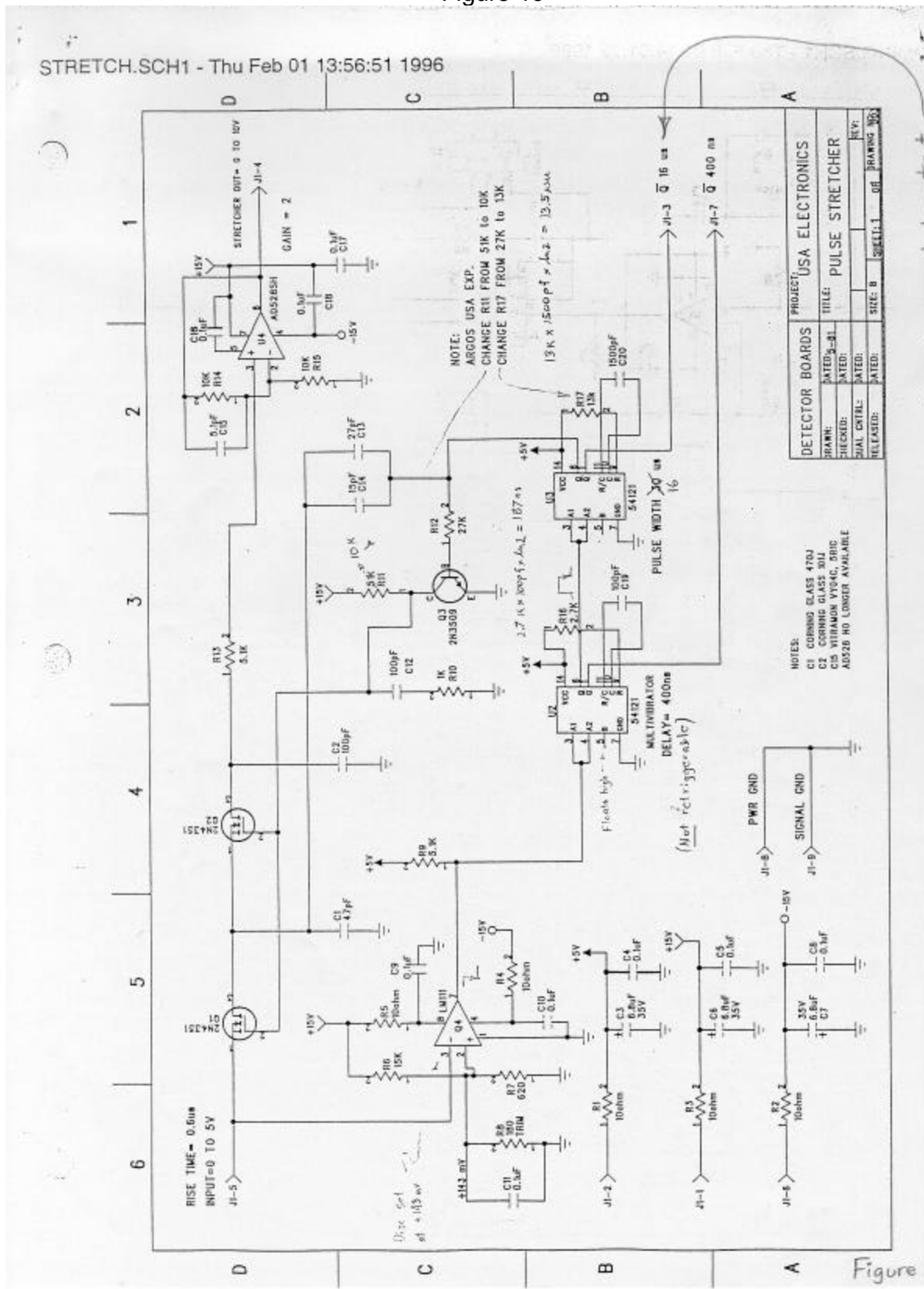


Figure 2

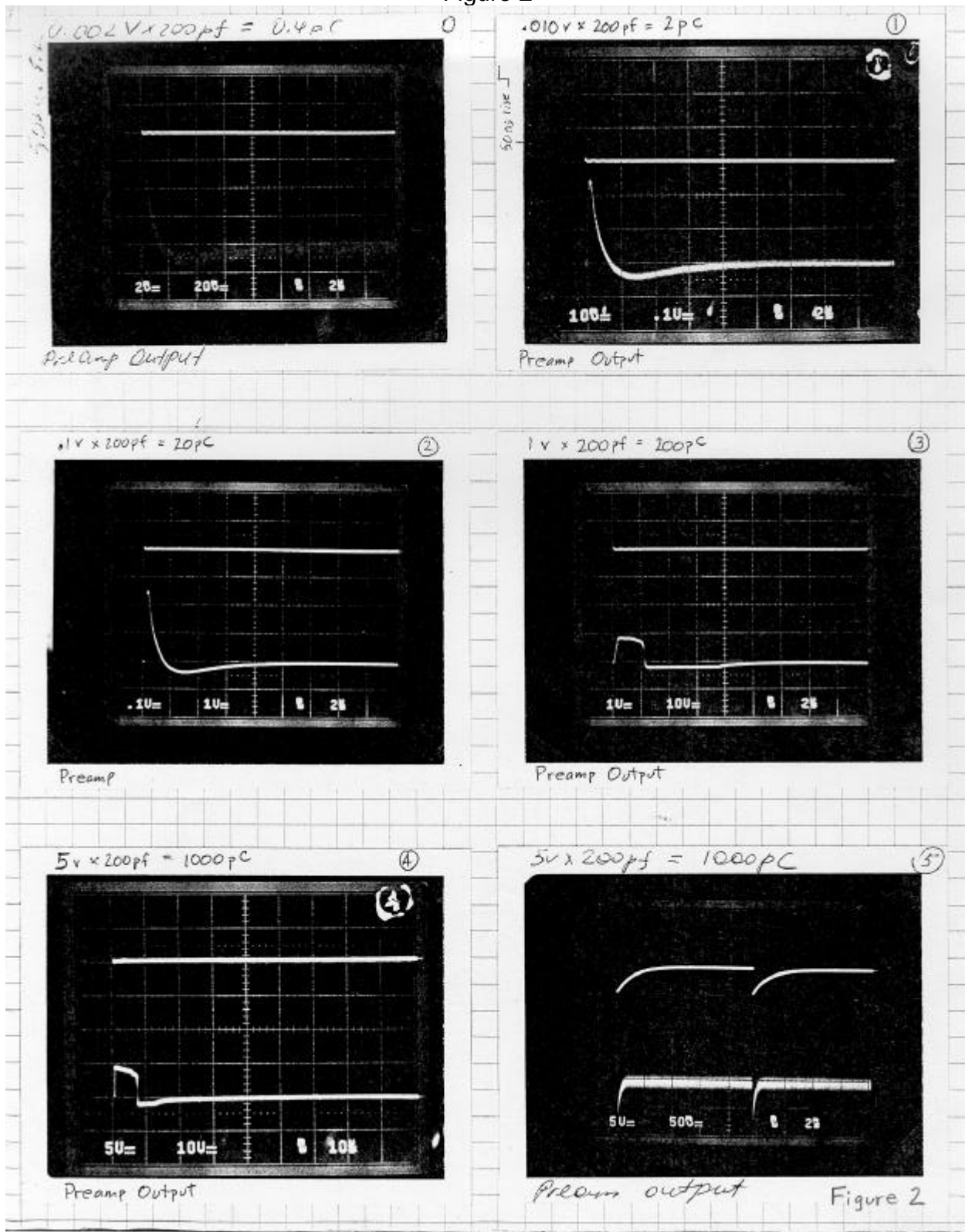


Figure 2



Figure 3

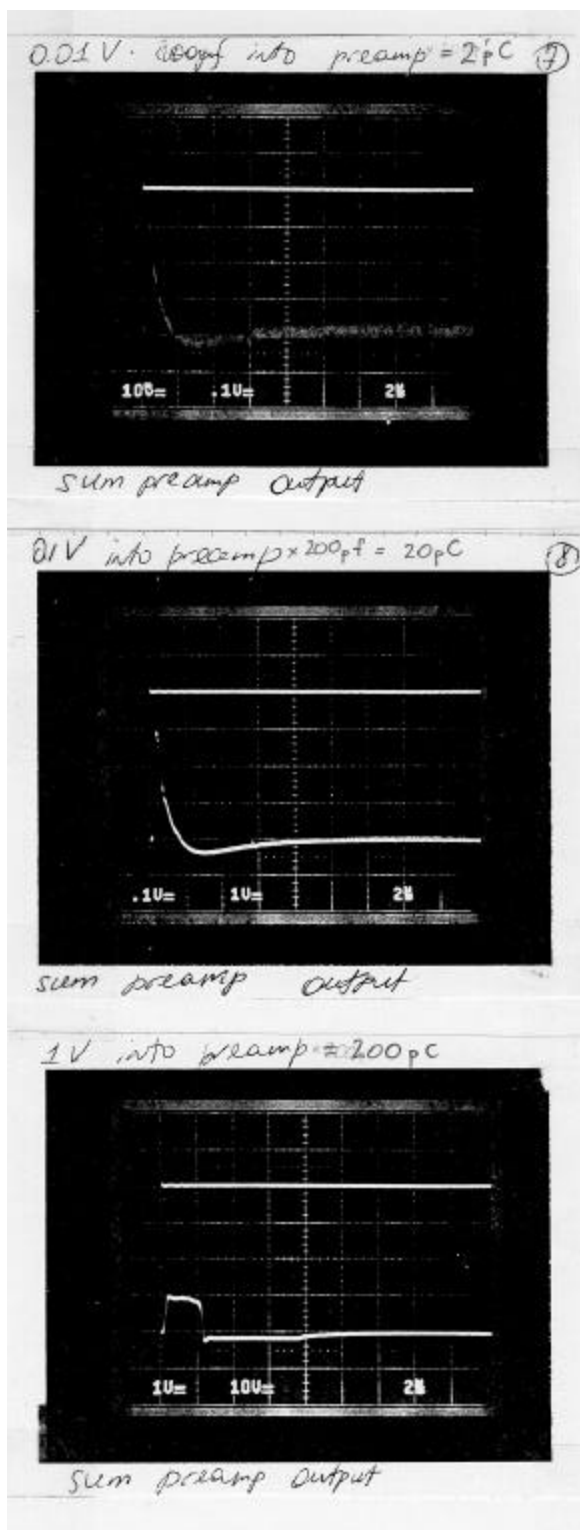


Figure 4

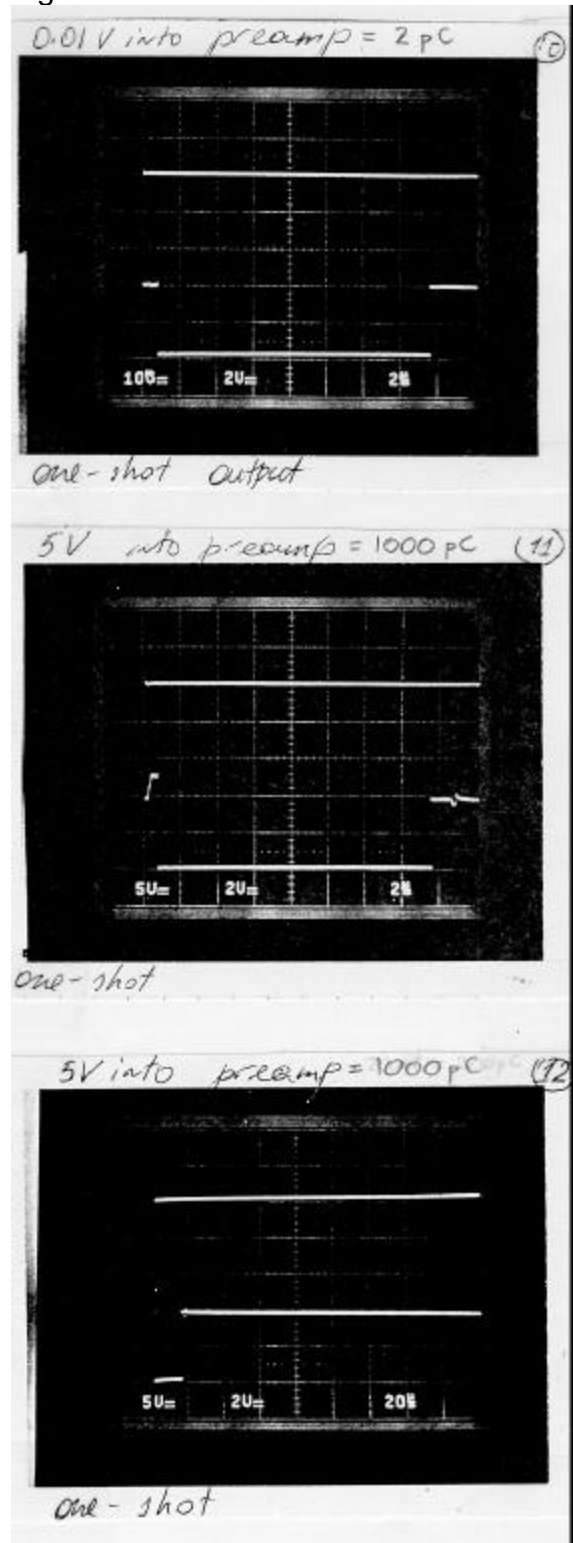


Figure 5

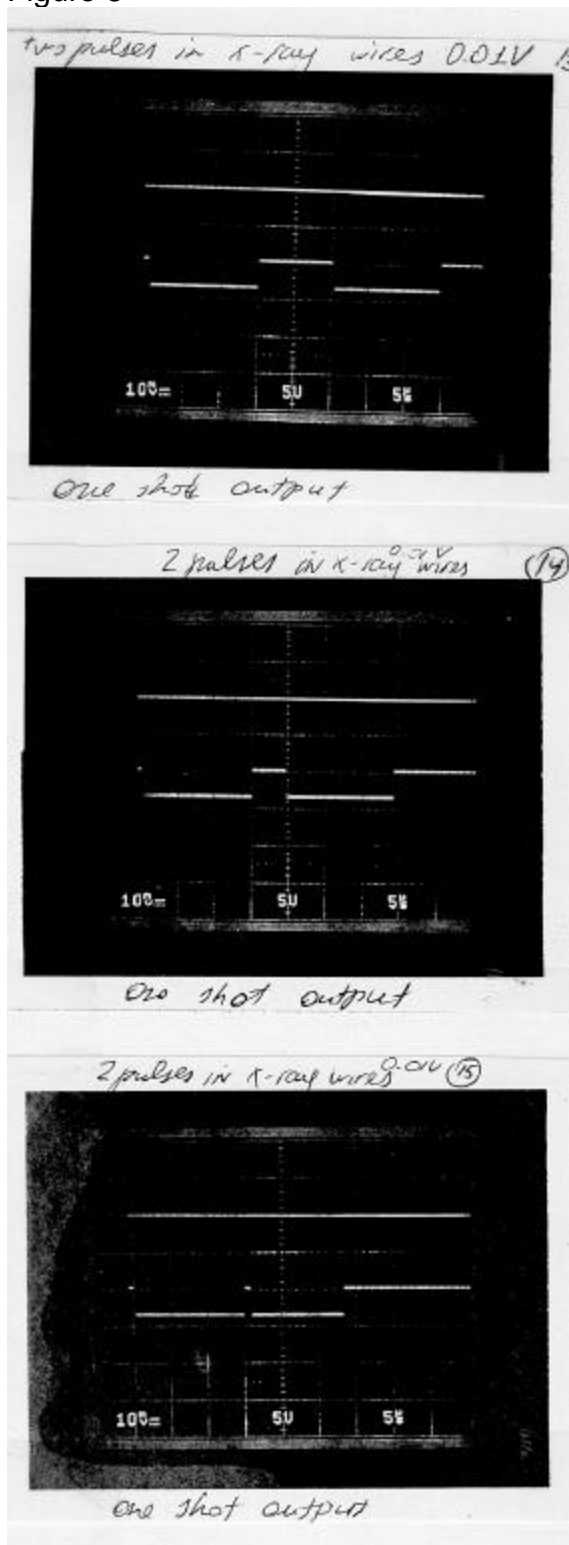


Figure 6

